

Lean Aerospace Initiative



**Enterprise Value:
The New Lean Horizon**

**Product Realization in the
Defense Aerospace Industry**
March 27, 2012

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2LT, USAF

Research Sponsored By Lean Aerospace Initiative

- **21st century aerospace challenge**
- **Industry maturity perspectives**
- **Implications on the aerospace industry**

Higher, Faster, Farther - The 21st Century Enterprise Challenge

Aerospace has four core missions:

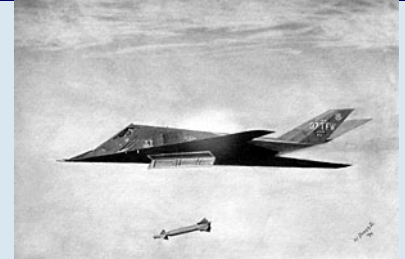
- Enabling the global movement of people and goods
- Enabling the global acquisition and dissemination of information and data
- Advancing national security interests
- Providing a source of inspiration by pushing the boundaries of exploration and innovation

These missions will never be routine and require the best technology and the best organizations

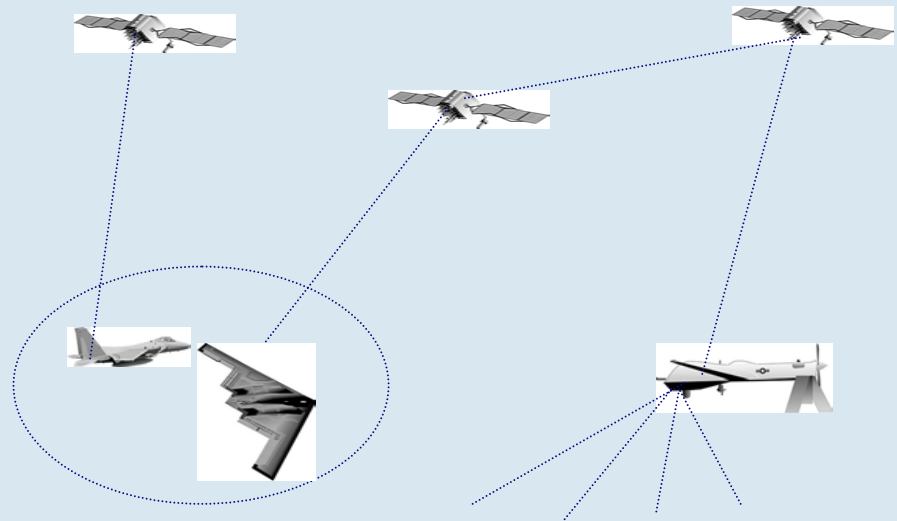
“The core challenge for industry in the 21st century involves identifying and delivering *value* to every stakeholder. Meeting that challenge requires *lean* capability at the *enterprise* level.”

The Needs of Aerospace Customers are Changing

**From a focus on single vehicles
to platforms...**



**To networks of platforms
and...**

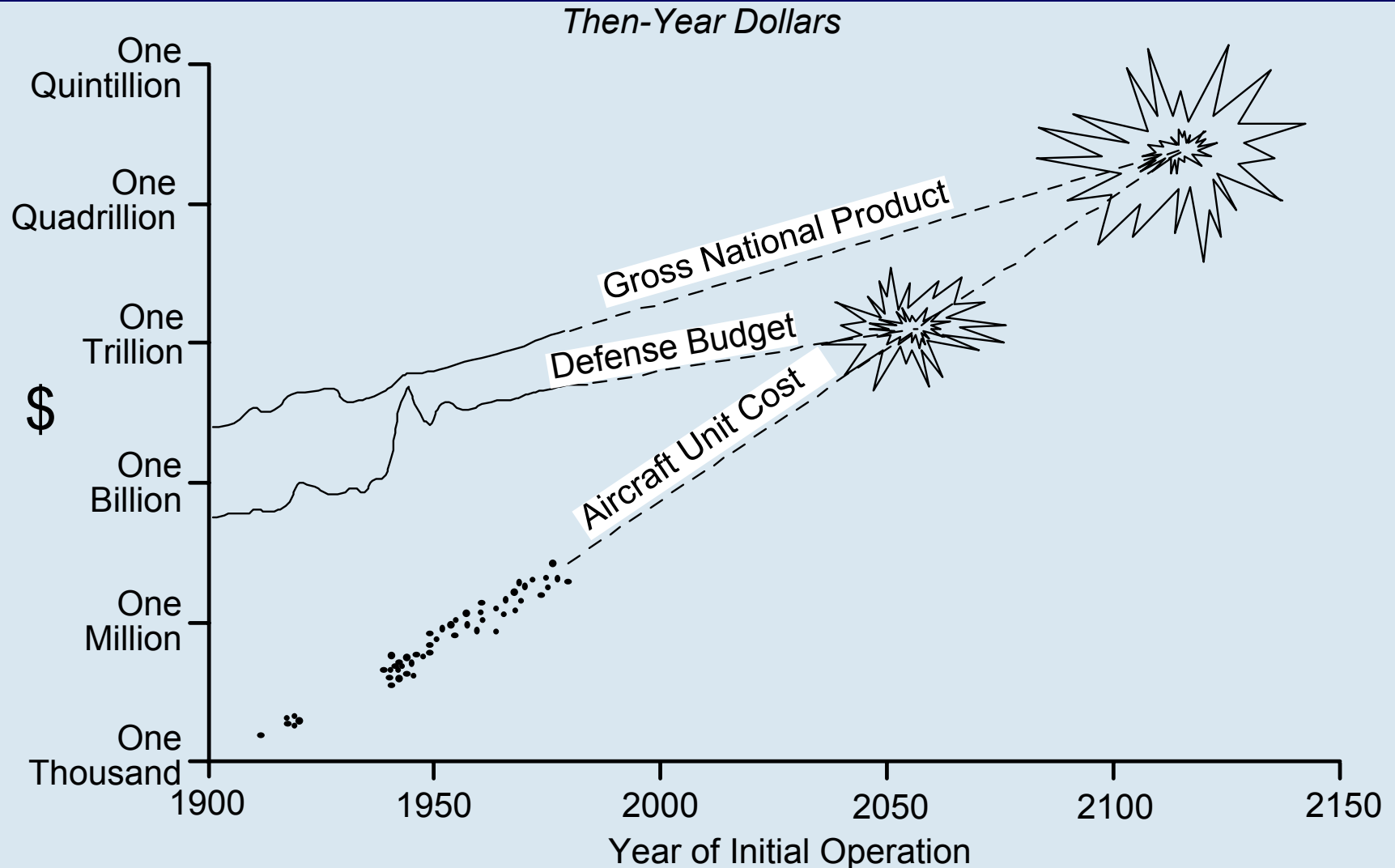


**More flexible challenges
in their employment**

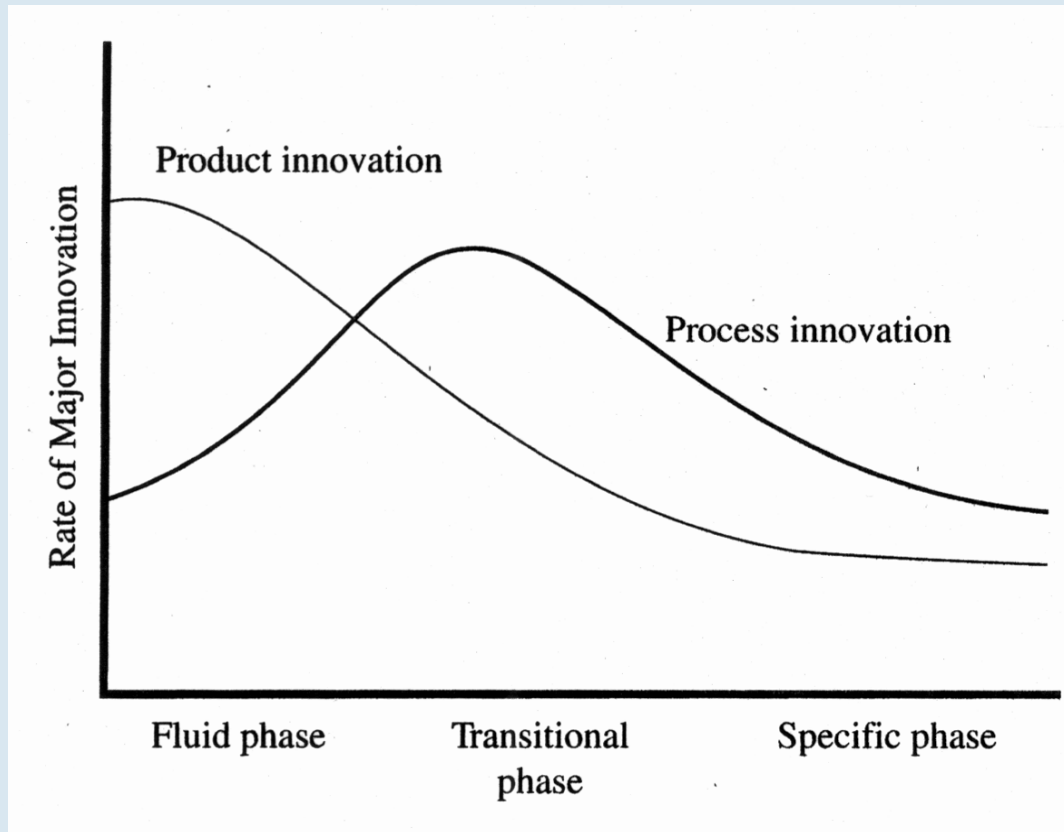
**Innovation in the industry is thus shifting from
single vehicles to networks of capability**

Cost of Tactical Aircraft

Source: Augustine's Laws



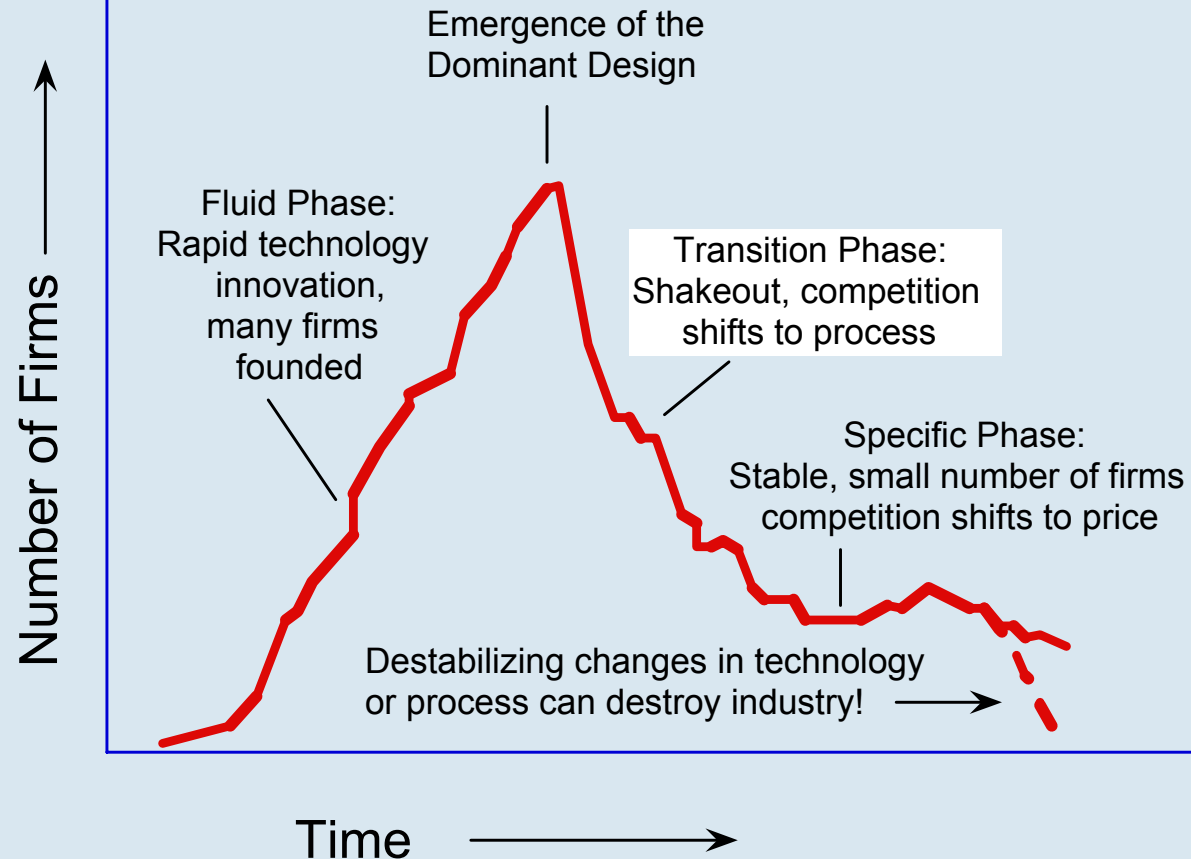
Model of Product and Process Innovation



- **Rate of product innovation highest during formative years**
- **As product matures rate of process innovation overcomes product innovation**
- **Very mature products have low levels of both product & process innovations**

Source: William Abernathy & James Utterback, 1978

Utterback's Dynamics of Innovation Model



Source: Utterback, *Dynamics of Innovation*, 1994 as adopted by Hugh McManus , 2001

Dominant Design?



1958



1995

Dominant Design?



1953

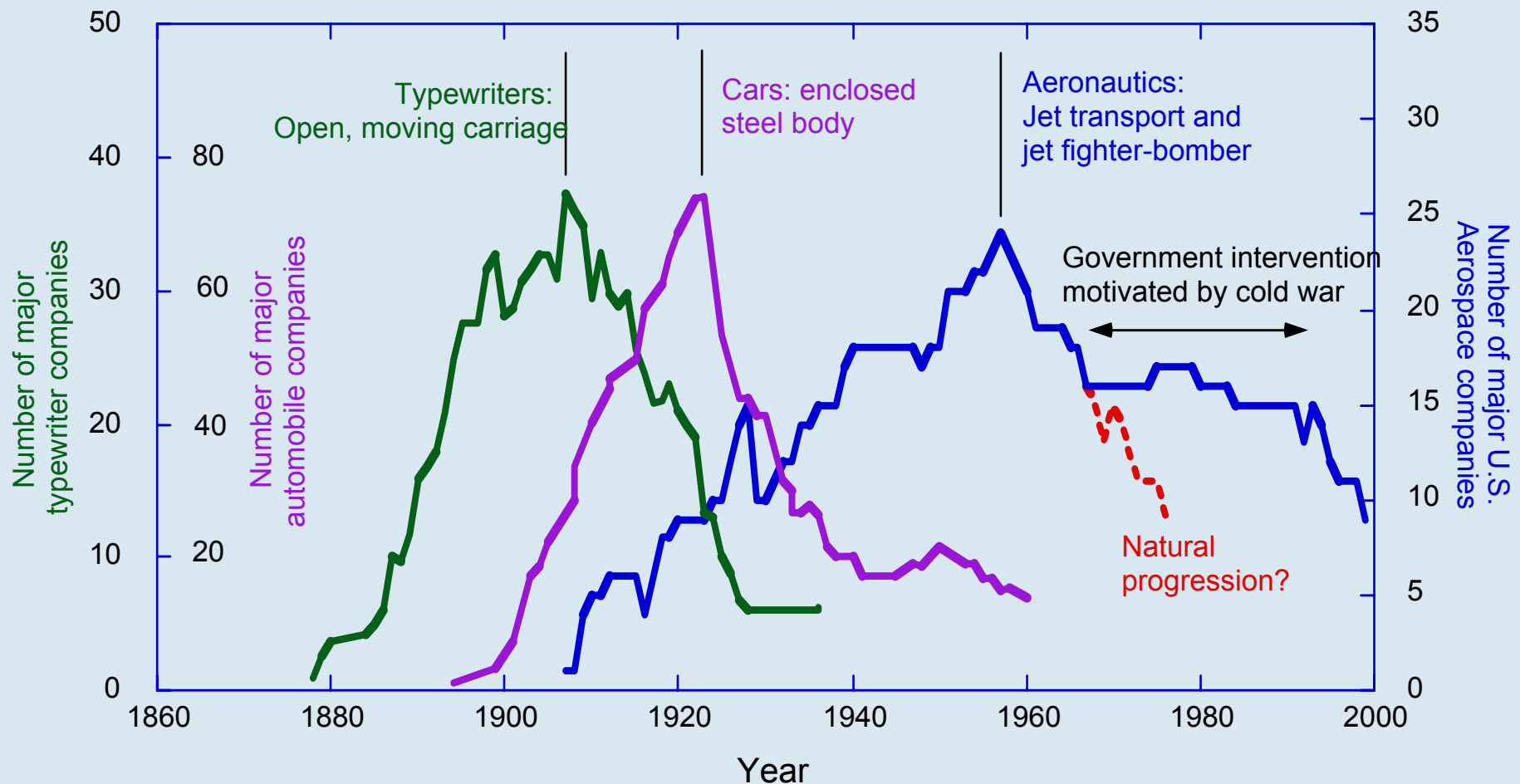


1972

2002



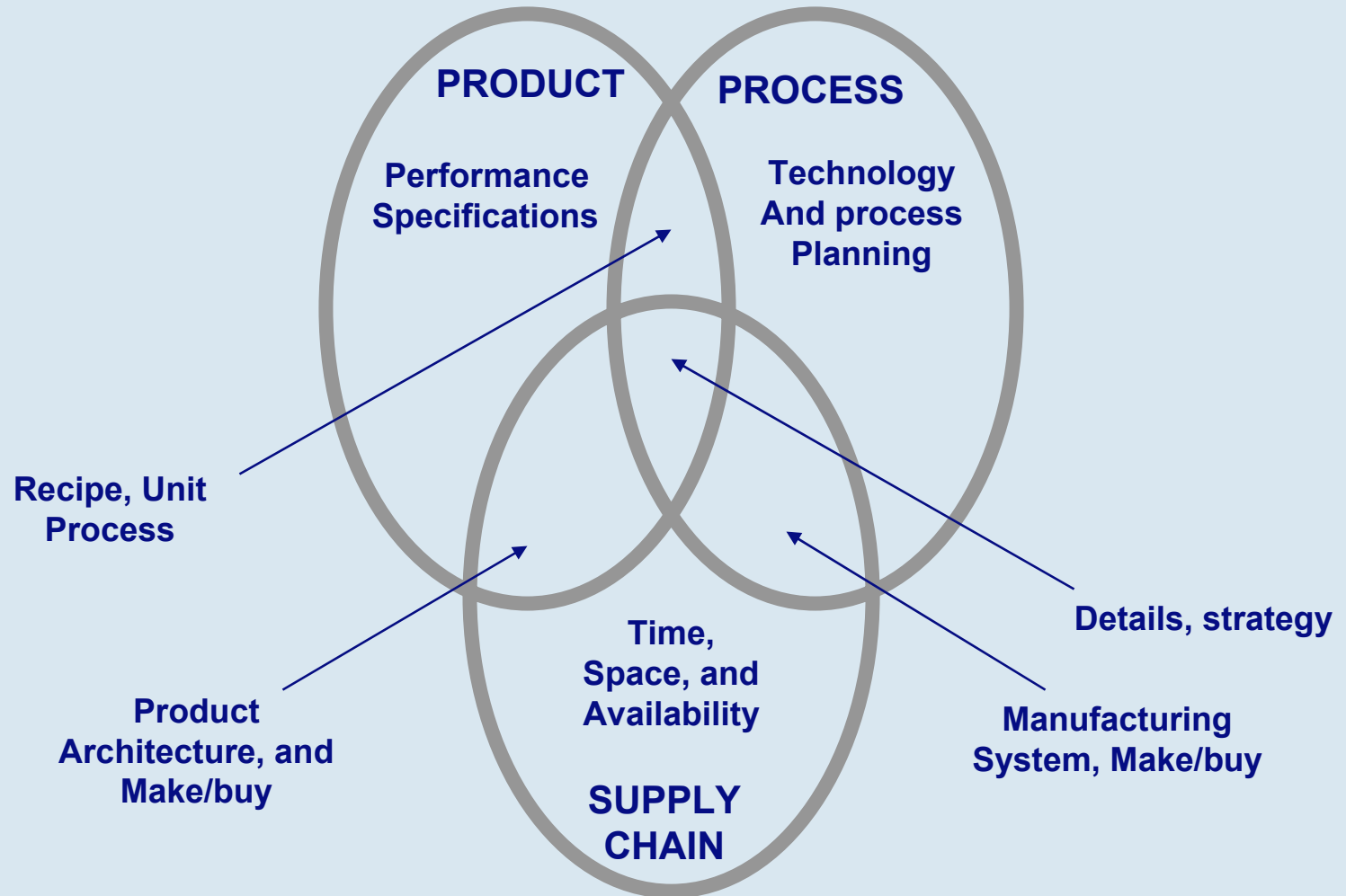
Industrial evolution and the emergence of the dominant design



- **Little product differentiation**
- **Incremental product innovation**
- **Acquisition cost becomes focus**
- **Operating costs more of a concern**
- **Mergers, acquisitions & exits**
- **Process innovation dominates**
- **Organizations become more rigid & hierarchical**
- **Less risk taking**

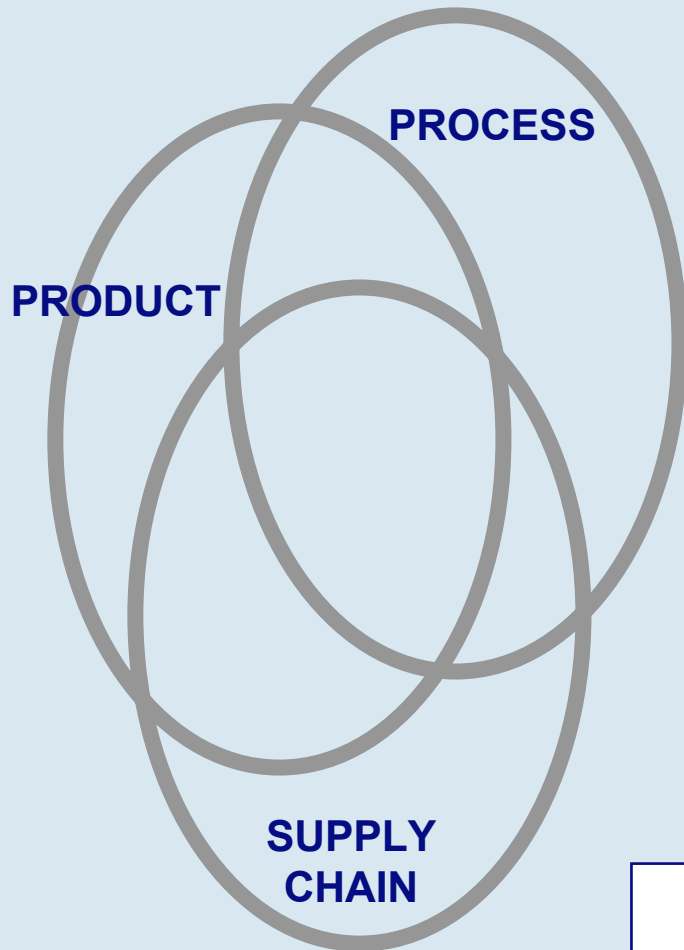
= AEROSPACE INDUSTRY?

Fine's 3-D Concurrent Engineering Model



Source: Charles Fine, *Clockspeed*, Perseus Books, p. 146

Fine's Model and the Aerospace Industry in the Transition Phase



In a post dominant design environment two relationships predominate

- **Product interactions become more interlinked with process and the supply chain**
- **Supply chain integration and process improvements have a predominant impact on cost**

Design must be much more interactive with mfg & suppliers

- **Aerospace industry innovation shifting to systems of systems**
- **In a maturing single product environment**
 - **Product and life cycle cost predominate**
 - **Best addressed by process & supply chain improvements**
- **Enterprise strategy should change in recognition of this new competitive landscape**

**Lean beyond the factory floor means shifting the enterprise focus from
*product design to product realization***

- **Research objectives**
- **Manufacturing System Design Framework**
- **Research Design**
- **Introduction of the case studies**
- **Results - with Bonus material!**
- **Conclusions**

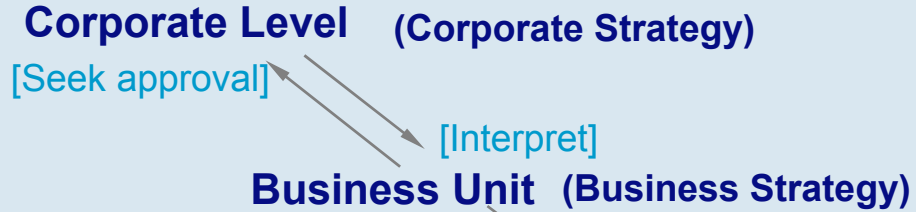
- **Goals guiding the research effort:**
 - **Study and improve available tools in use**
 - **Understand the processes used in industry to design manufacturing systems**
 - **Propose a model for industry to use**
 - **Test this model in industry**
 - **Establish key characteristics of this design process**
- **Create analytical models to predict manufacturing system performance**

Elements for a Manufacturing System Design Framework

- A holistic view of manufacturing system design environment
- Visual depiction of “design beyond factory floor” ideas
- Manufacturing as part of the product strategy
- *Manufacturing system design is strategy driven, not product design driven*
- Combines multiple useful tools
- Provides insights into order and interactions
- Not prescriptive
- Can lead to innovative & new manufacturing system designs
- Shows the unending design cycle -- Continuous Improvement

- **Manufacturing system “infrastructure” design**
 - **Manufacturing strategy**
 - **Operating policy**
 - **Partnerships (suppliers)**
 - **Organization structure details**

- **Manufacturing system “structure” design**
 - **Buildings, location, capacity**
 - **Machine selection**
 - **Layout**
 - **WIP**



Stakeholders

Manufacturing System Design

Corporate Level

[Seek approval]

[Interpret]

Business Unit

Product Strategy

Suppliers

Product Design

Manufacturing

Marketing

Make/Buy
Risk-sharing Partnerships

DFMA, IPT
3-DCE
Concurrent Engineering

Customer Needs
Technical Feasibility
Feasible performance guarantees

Requirements/Considerations/Constraints

- Miltenburg, - 3P, - 2D plots,
- MSDD, - AMSDD - design Kaizen

Manufacturing System Design/Selection

- Analytical Tools,
- Simulation Tools

Implement (pilot)

Fine Tune

Evaluate/Validate

• VSM
• Kaizen
• Trial & Error
• Kaikaku

Modifications

Finalized Product Design

Rate Production

Stakeholders

Manufacturing System Design

Corporate Level

[Seek approval]

[Interpret]

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Modifications

Finalized Product Design

Rate Production

- **Assembly operations**
- **Site selection criteria**
- **Framework Evaluation Tool**
- **Performance Metric**

- **30+ site visits since June 2000**
- **Over 240 interviews ranging from vice presidents to shop floor workers**
- **Real time “fly on the wall” or retrospective observations**

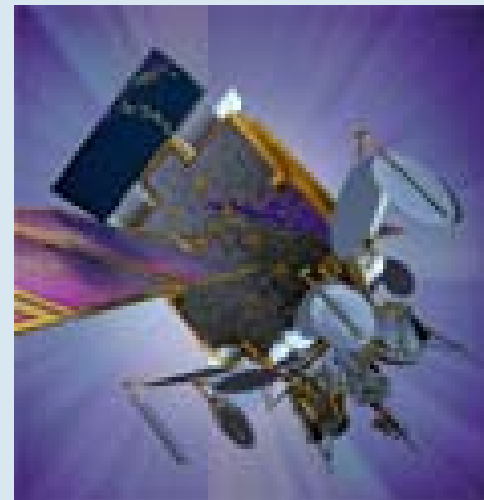
- **Major Aerostructures (6):**
 - 737NG, F-18 E/F EFF, F-16, F-22 (wing/aft, mid), X-35
- **Electronics (2):**
 - Wedgetail, TDR-94



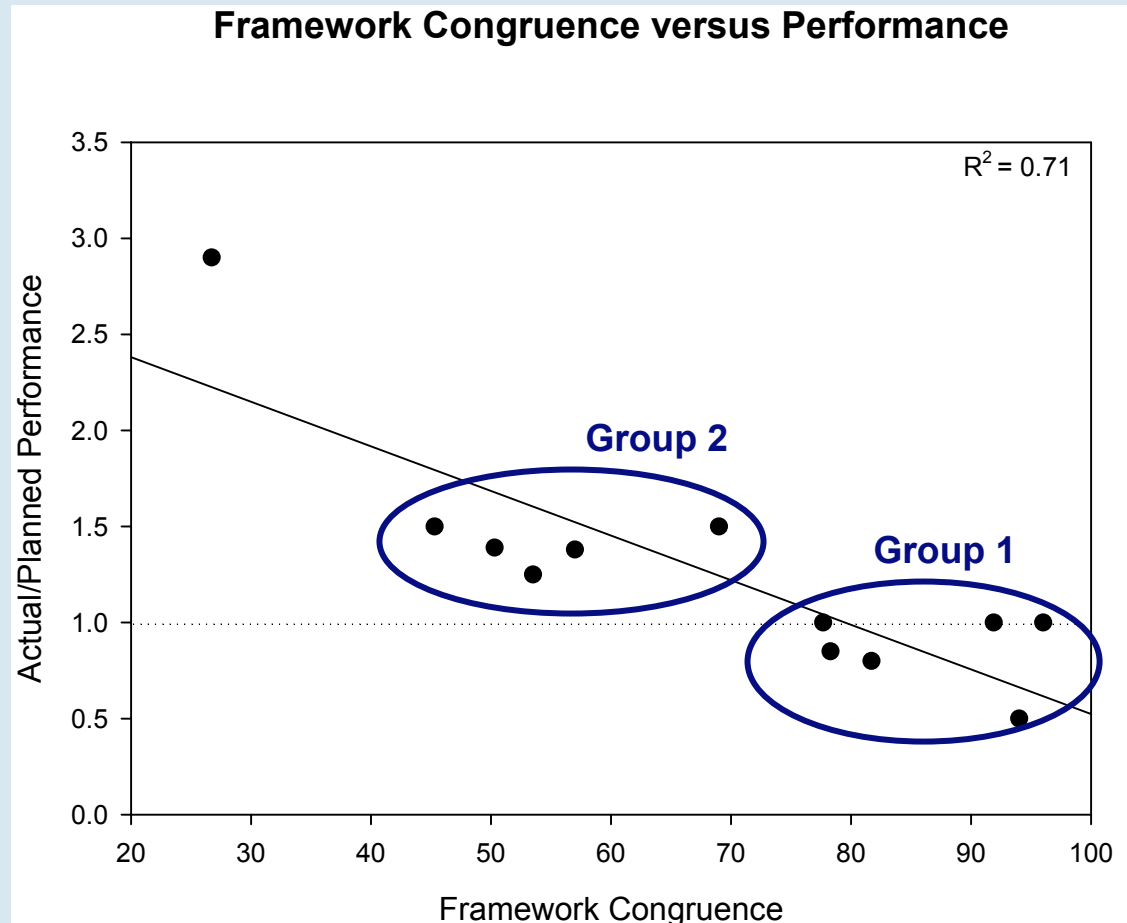
Case Studies - Space



- **Launch Vehicles (2):**
 - **EELV: Atlas V, Delta IV**
- **Space (4):**
 - **A2100, AEHF, Iridium, HVSP**



Framework Validation Results

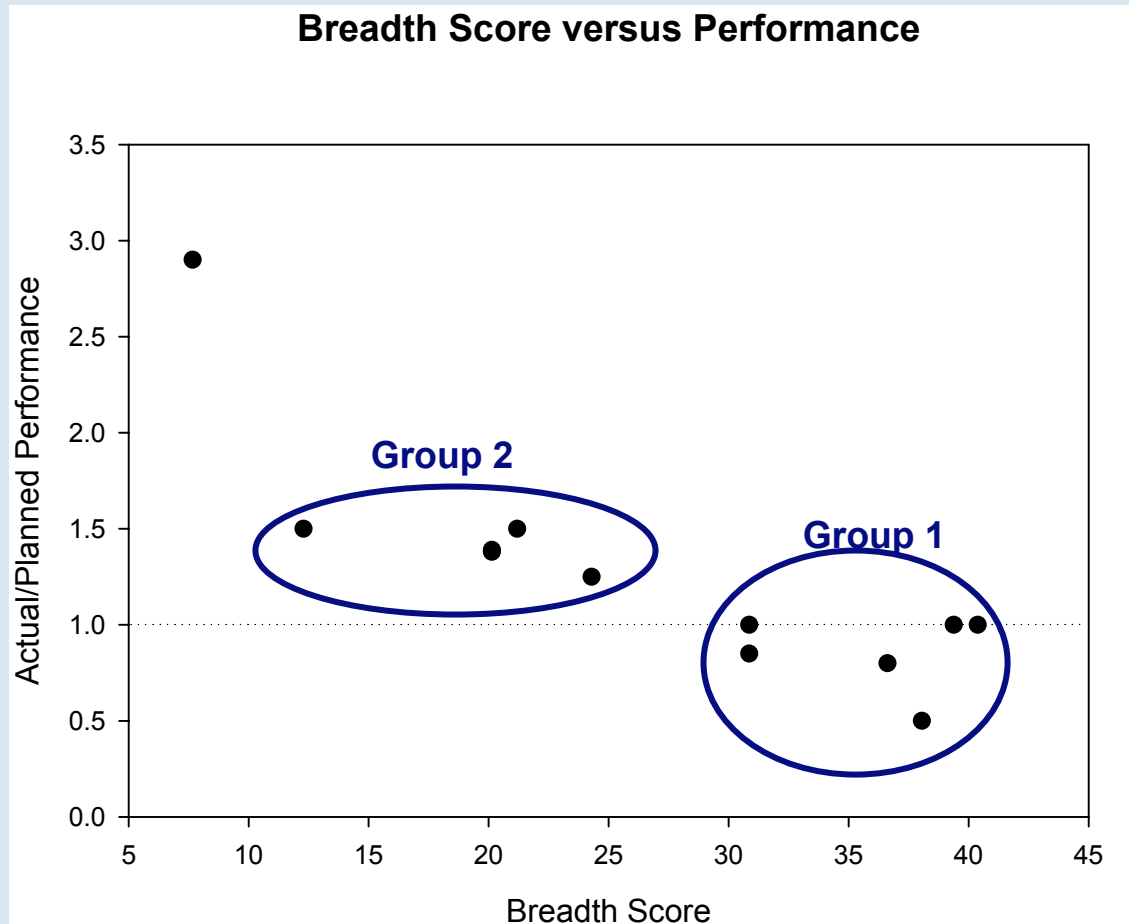


Scoring Breakdown

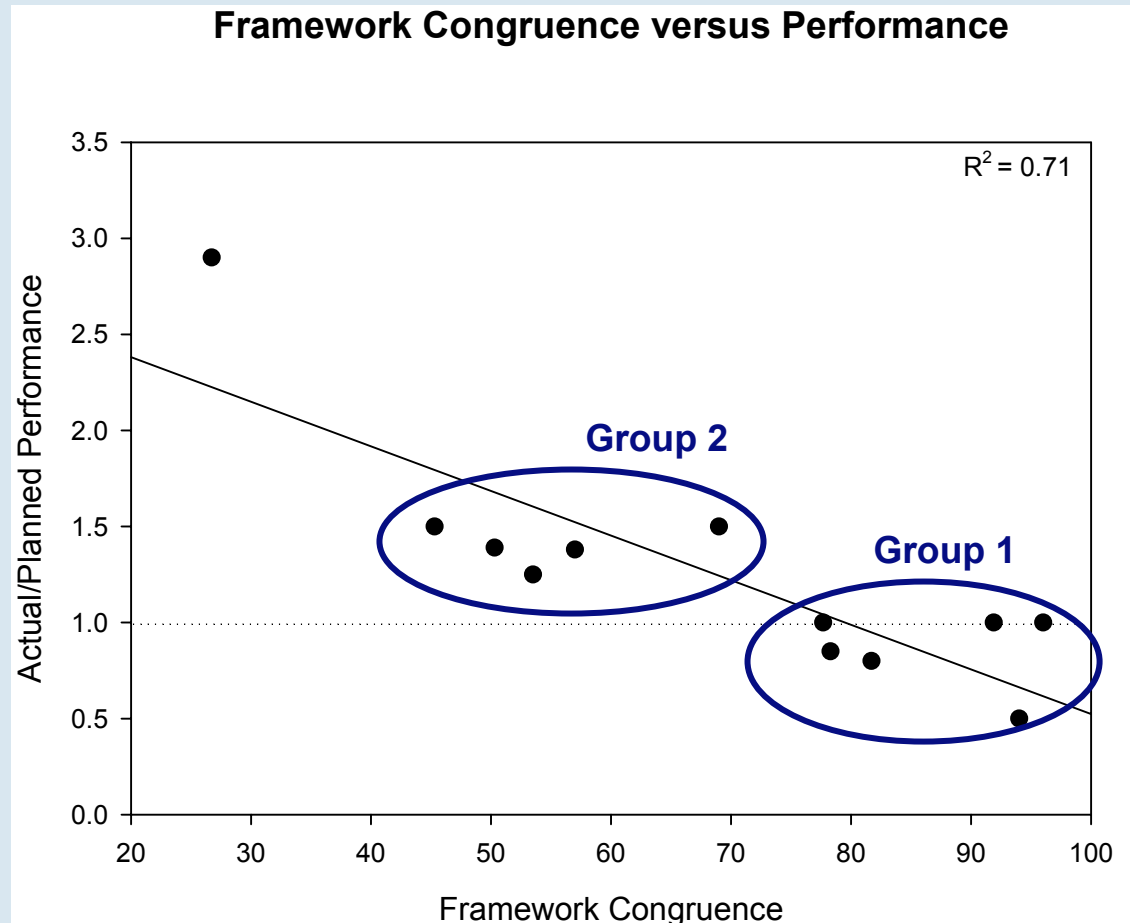
Framework Congruence	Phase Presence	Timing	Breadth	
96	25.90	30.71	39.38	Group 1
94	25.90	30.00	38.05	
91.9	22.48	29.00	40.38	
81.7	18.57	26.62	36.62	
78.3	23.24	24.19	30.86	
77.67	20.90	25.90	30.86	
69	21.24	26.62	21.19	Group 2
57	17.24	19.76	20.14	
53.5	13.33	15.90	24.29	
50.3	12.33	17.90	20.14	
45.3	15.00	18.76	12.29	
26.73	7.33	11.76	7.67	

- How important are the different aspects?
 - Which of Phase Presence, Timing or Breadth impacted the ability of the system to meet its planned performance?

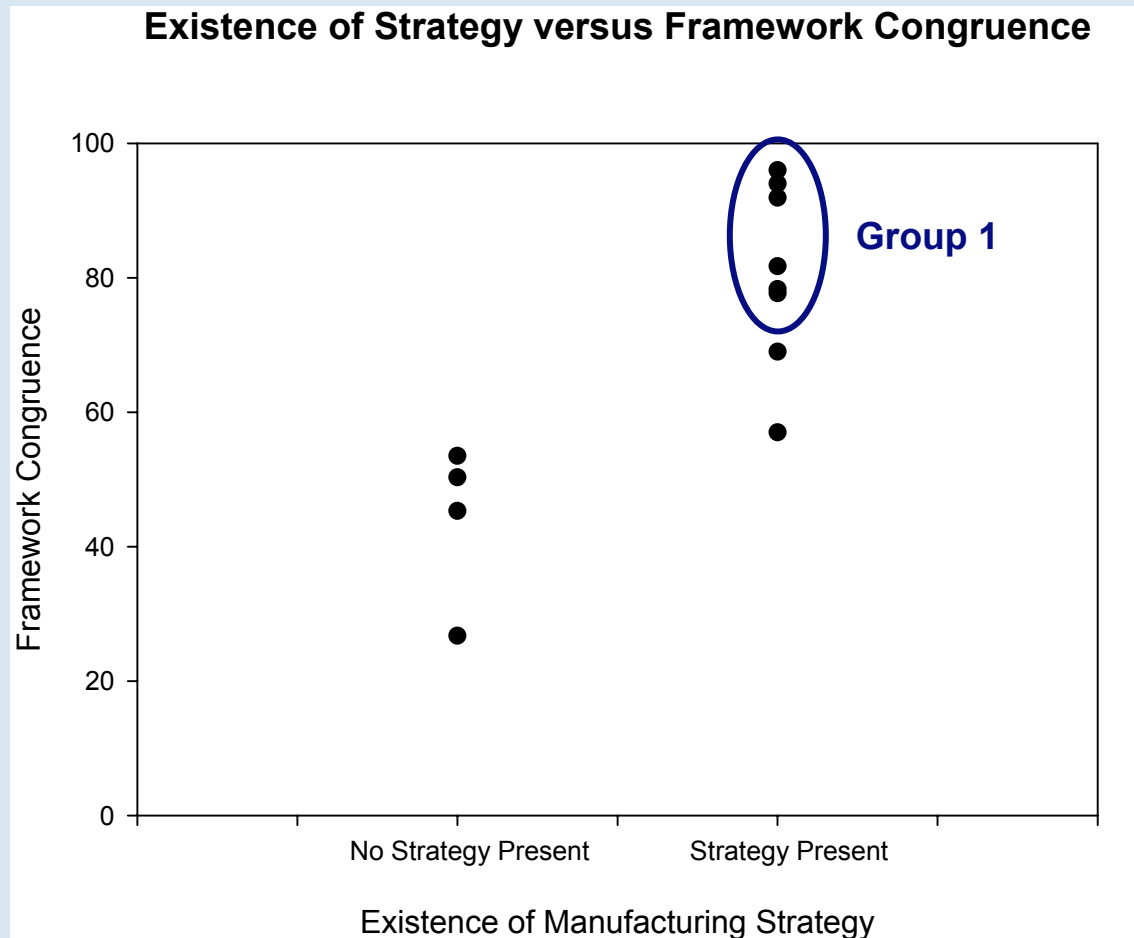
Determinants of Performance

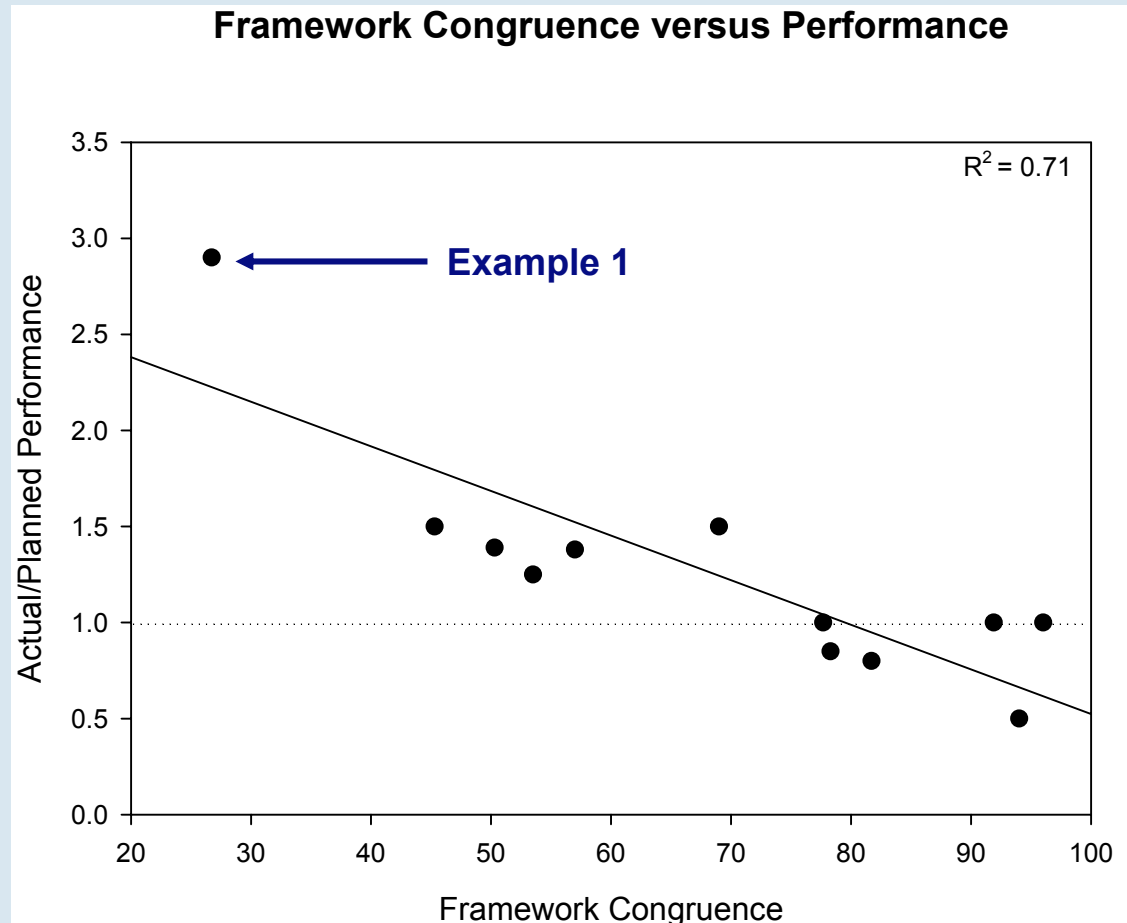


Framework Validation Results



Strategy Presence Results





Stakeholders

Manufacturing System Design Example 1

Corporate Level

Corporate Goals
Manufacturing

Business Unit

Manufacturing System Design/Selection

- Review Requirements
- Picked Cells

Implement (pilot)

Fine Tune
Simulations

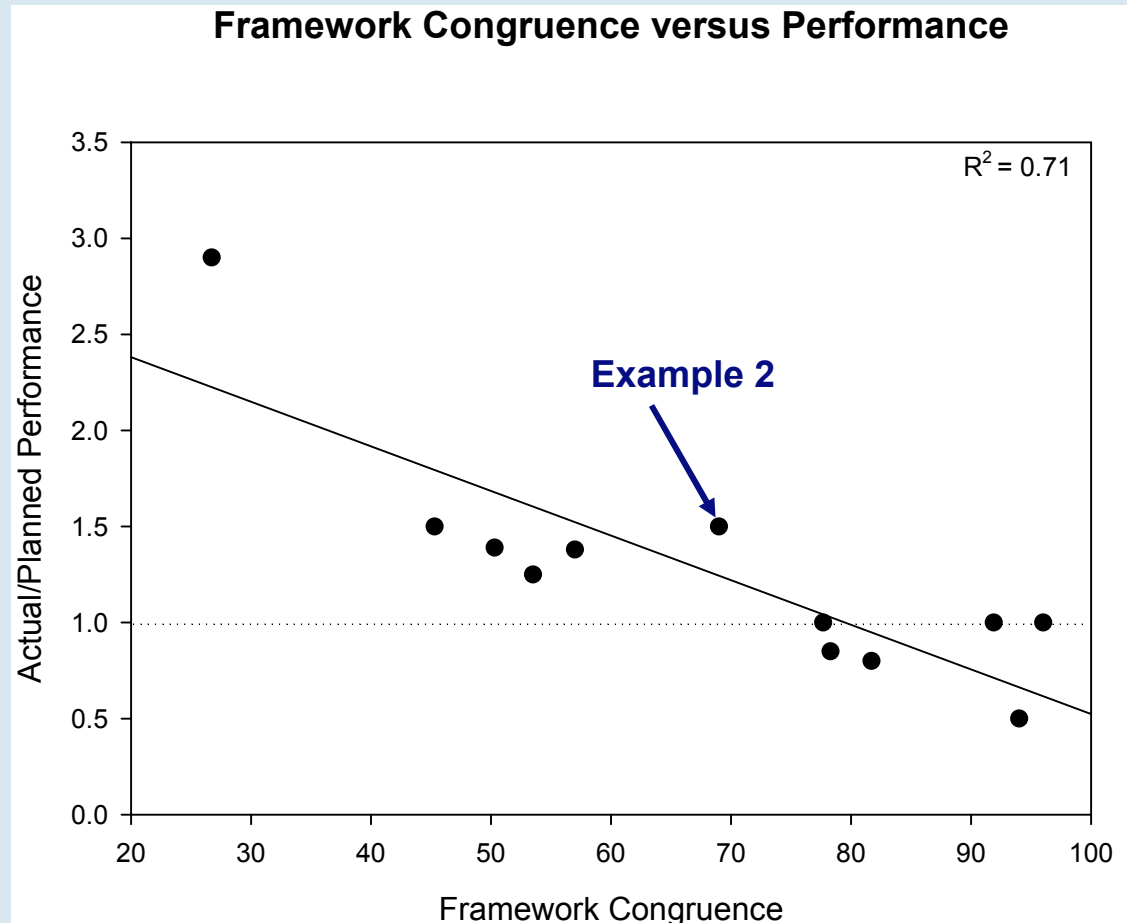
Evaluate/Validate

- VSM
- Kaizen
- Trial & Error
- 5S

Modifications

Finalized Product Design

Rate Production



Stakeholders

Manufacturing System Design Example 2

Corporate Level

[Seek approval]

[Interpret]

Business Unit

Product Strategy

Suppliers

Product Design

Manufacturing

Marketing

Customer Needs

Technical Feasibility

Feasible performance guarantees

Requirements/Considerations/Constraints

3P

Outside Intervention

Manufacturing System Design/Selection

Simulation Tools

Implement (pilot)

Fine Tune

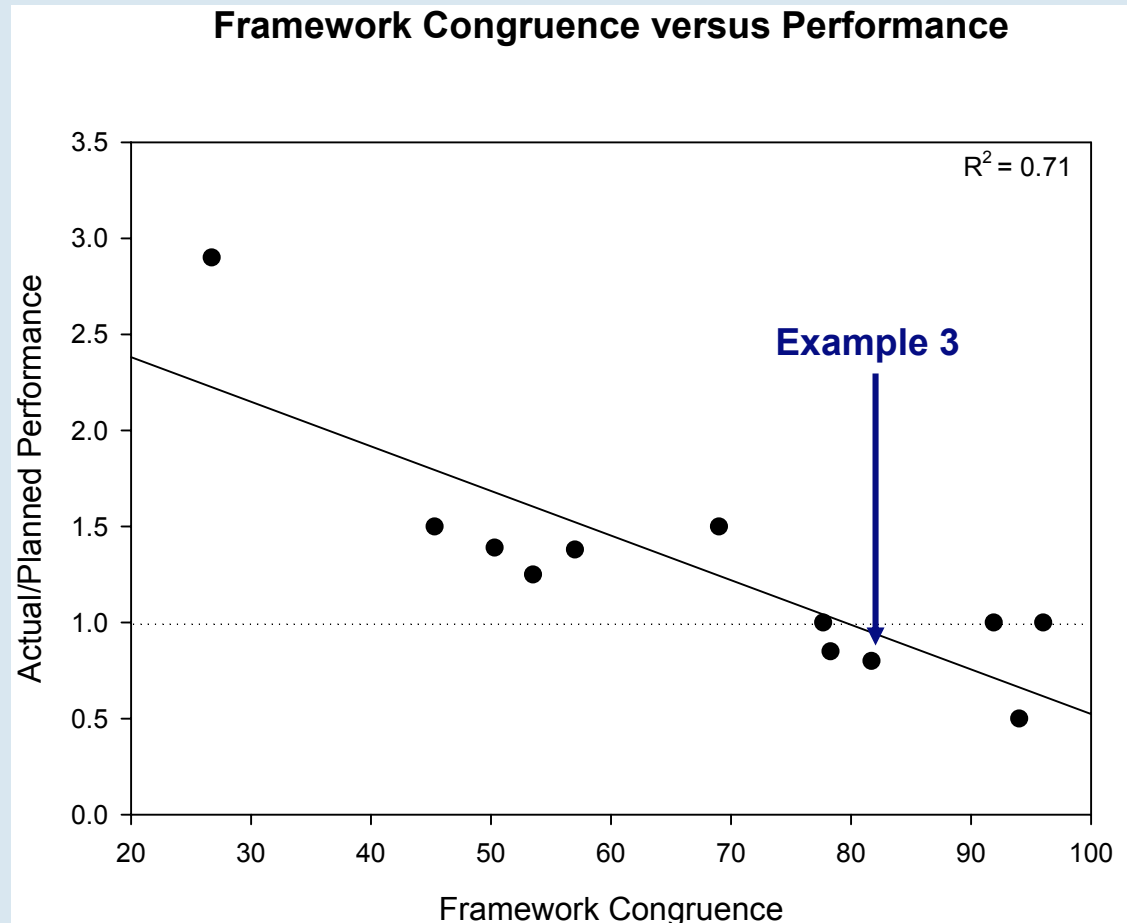
Evaluate/Validate

- VSM
- Kaizen

Modifications

Finalized Product Design

Rate Production



Stakeholders

Manufacturing System Design Example 3

Corporate Level

[Seek approval]

[Interpret]

Business Unit

Product Strategy (all products)

Suppliers

Product Design

Manufacturing

Marketing

Make/Buy
Risk-sharing Partnerships

DFMA, IPT
Concurrent Engineering

Customer Needs
Technical Feasibility
Feasible performance guarantees

Requirements/Considerations/Constraints

Manufacturing System Design/Selection

Pre-Design Kaizen
Simulation Tools

Implement (pilot)

Fine Tune

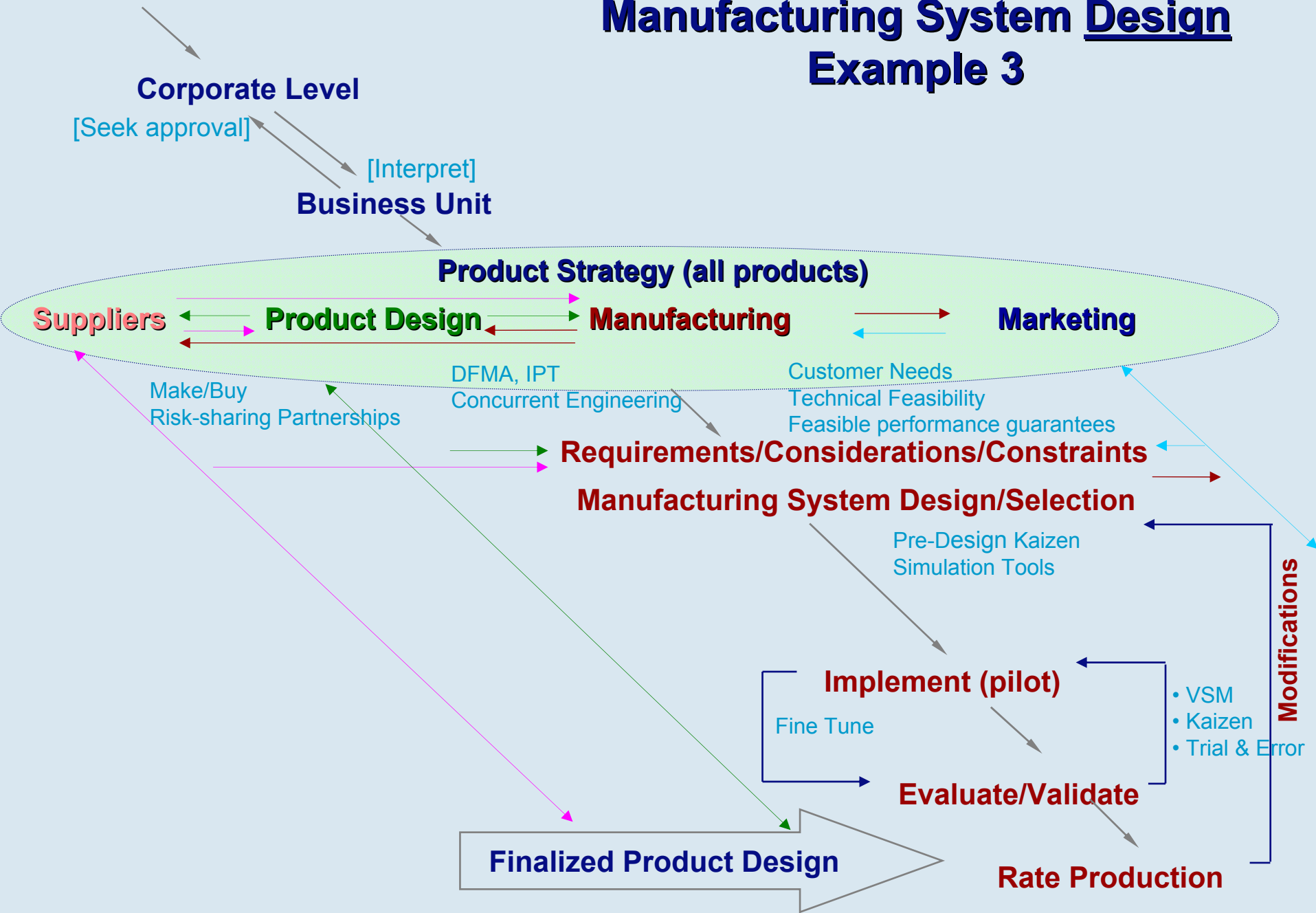
Evaluate/Validate

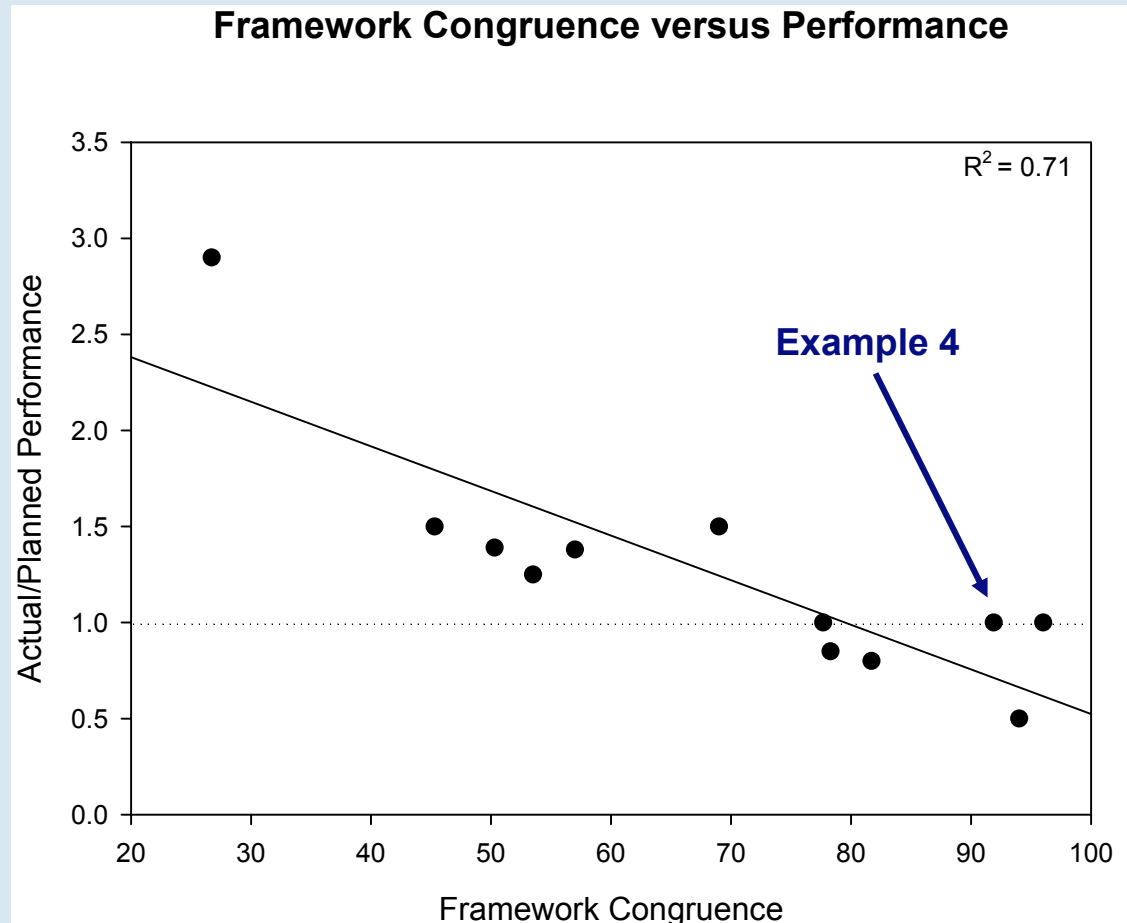
- VSM
- Kaizen
- Trial & Error

Modifications

Finalized Product Design

Rate Production





Stakeholders

Manufacturing System Design Example 4

Corporate Level

[Seek approval]

[Interpret]

Business Unit

Enterprise Wide Product Strategy

Suppliers

Product Design

Manufacturing

Marketing

Make/Buy
Best Value

DFMA, IPT
Concurrent Engineering

Customer Needs
Technical Feasibility
Feasible performance guarantees

Requirements/Considerations/Constraints

Manufacturing System Design/Selection

- Simulation Tools
- Scale Models

Implement (pilot)

Pilot Plant
Pathfinder

Evaluate/Validate

• VSM
• Kaizen
• 6-sigma

Modifications

Finalized Product Design

Rate Production

- **The role of manufacturing as a source for competitive advantage**
- **Framework Validation**
 - **Framework congruence and system performance**
- **Key Characteristics**
 - **Breadth**
 - **Strategy**
 - **Status**